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Medical Information

Lead in the Blood of California Children

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LEAD IS UBIQUITOUS in the environment, being found in air, water, food, dirt, dust, paint and, as a result of ingestion and inhalation, in humans.[1-3] An excess body burden of lead is associated with a variety of health problems which can have severe individual and societal consequences. The major systems affected are the nervous, gastrointestinal and hematopoietic. The effects on the nervous system range from mild neurological disabilities and hyperactivity to mental retardation and acute encephalopathy.[3] Gastrointestinal manifestations of lead toxicity are loss of appetite, abdominal colic or cramping pain, constipation, nausea and weight loss. The major effect of lead on the blood is reduction in hemoglobin production as well as increased red blood cell destruction.[1,3]

Children, particularly those with pica, the habit of eating nonfood items, are susceptible to an increased body burden of lead. Until recently, it was believed that most of the problems of elevated blood levels of lead in children existed in the East and Midwest, especially in areas of rundown inner-city lead-painted housing.[4] In 1975, the Center for Disease Control (CDC) funded a lead-poisoning prevention program in Los Angeles, Contra Costa and Alameda Counties. The purpose of this paper is to present the data from the first year of that program. The paper is restricted to the screening aspect of the program. A later paper will discuss the other equally important aspects, namely pediatric follow-up, and source identification and removal.

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ABBREVIATIONS USED IN TEXT

AIHL = Air and Industrial Hygiene Laboratory
CDC = Center for Disease Control
EP = erythrocyte protoporphyrin

The Screening Program

The primary goal of the entire program is to prevent lead poisoning by the early detection of children with increased lead absorption, followed by effective medical and environmental intervention. Consequently, the population groups to be screened were chosen to create a maximum probability of finding children at risk. In almost all cases only children under 6 years old were screened. In Los Angeles, the criteria used to select the census tracts were that 70 percent of the houses were constructed before 1939, a significant number were deteriorating, a higher than average number of families fell below the poverty level and each tract contained at least 500 children less than 6 years of age. Similar criteria were used in Alameda and Contra Costa Counties. After applying these factors, the Watts-Florence-Firestone area in southeast Los Angeles was chosen for lead screening. The area is located between two major freeways and has some heavy industry. Approximately two thirds of the population is black and one third Chicano, with a total population under 6 years old estimated at 13,700. In Alameda County, an area in West Oakland with industry and bounded by freeways (many of them elevated) was chosen. A belt of land containing industry north of Berkeley along the eastern shore of San Francisco Bay was selected in Contra Costa County.

Blood samples were obtained by county health department workers, mostly on a door-to-door canvass. The Air and Industrial Hygiene Laboratory (AIHL) supplied the counties with standardized microcollection kits manufactured by Trace Metals, Inc.* Venous samples were col-

*Mention of commercial products is not to be construed as an actual or implied endorsement.

lected in 10 ml heparinized "minimal lead" Becton-Dickinson Vacutainers®.

In this program, a capillary finger stick sample was usually employed for the initial screen (Contra Costa collected venous samples whenever possible). These micro-samples are easily contaminated by lead, particularly during the collection processes. Comparisons in the laboratory between values obtained by simultaneous finger stick and venous collection showed good agreement under these ideal conditions, but it was not possible to carry out such experiments in the field program.

To reduce errors in identification of children at risk due to contamination, each blood specimen was tested for both blood lead and erythrocyte protoporphyrin (EP), a gauge of the metabolic effect of lead. (Protoporphyrin combines with iron to form heme which, with globin, forms hemoglobin. Lead blocks this process and the excess protoporphyrin accumulates in the red blood cells. EP is usually expressed in micrograms of free erythrocyte protoporphyrin (FEP) as μg per 100 ml of whole blood.) Also, EP is less subject to physiological changes and is a better index than blood lead measurements of potential toxicity from the body's lead burden.[5,6] However, elevated EP levels (above 60 μg per 100 ml) may also be due to other conditions such as chronic inflammation and iron deficiency. According to CDC guidelines, in those children with an EP level greater than 60 μg per 100 ml and a blood lead level greater than 30 μg per 100 ml there should be a follow-up with a second test. The follow-up was usually done by venipuncture.

Measurement Techniques

The specimens from all three counties were analyzed either by the AIHL or the Sacramento County Health Department Laboratory using the same analytical methods. The EP was determined by the ethyl acetate-acetic acid-HCL method of Chisholm and Brown[8] and the concentration read on a fluorometer calibrated with protoporphyrin IX standards. The lead analysis was done by atomic absorption using a modification of the Delves method.[9,10]

Both laboratories participated in the monthly CDC lead and EP proficiency testing program, and AIHL also participated in the New York State Health Department's Lead and EP Proficiency Testing Programs. Blood lead standards which were used by both AIHL and the Sacramento laboratory were prepared quarterly at AIHL using blood from steers that had been fed lead acetate. These standards were analyzed by four reference laboratories outside of California that used three different analytical techniques: Delves cup, carbon-rod atomic absorption and anodic stripping voltammetry. Agreement among the four reference laboratories was excellent. The results of these programs plus a number of "blind" interlaboratory comparisons of split samples indicated that the laboratories were proficient in lead and EP analysis.

Results

The results of the dual screening program for Los Angeles County from December 1, 1975, through August 1, 1976, are listed in Table 1. The blood lead and EP categories were chosen to conform to CDC guidelines.[7] If an initial test yielded a low EP value, but a high lead level, and was followed by another test that showed low lead and EP values, the initial sample was assumed to be contaminated and only the second test was included in the table. A total of 281 children or 23 percent of the 1,239 tested had elevated blood lead and EP (30 μg per 100 ml or greater and 60 μg per 100 ml or greater, respectively). It is important that these children receive follow-up testing to confirm the initial test so that the child can be given appropriate

TABLE 1.—*Results of Dual Screening in Los Angeles*
DECEMBER 1, 1975 TO AUGUST 1, 1976

Blood Lead μg/100 ml	Erythrocyte Protoporphyrin (EP)—μg/100 ml: <60 Number	<60 Percent	60<110 Number	60<110 Percent	110<190 Number	110<190 Percent	190+ Number	190+ Percent	TOTAL* Number	TOTAL* Percent
<30	431	34.8	86	6.9	13	1.0	6	0.5	536	43.3
30<50	399	32.2	154	12.4	62	5.0	19	1.5	634	51.2
50<80	22	1.8	16	1.3	13	1.0	15	1.2	66	5.3
80+	1	0.1	..	..	..	..	2	0.2	3	0.2
TOTAL*	853	68.8	256	20.7	88	7.1	42	3.4	1,239	100.0

*Column and row percent figures may not add exactly to totals due to rounding off.

medical care. Unfortunately, some children could not be retested for various reasons. However, of those retested, usually by venipuncture, approximately 60 percent remained in their initial category or went to a higher one. There is no way to show clearly why a child went down in class upon retest, but besides the important possibility of contamination of the initial sample, other causes such as more parental guidance or the elimination of the source, or physiological fluctuations are possible. In some cases there was a delay of weeks or more before a child could be retested. Therefore, the crucial question of what percentage of the children in these particular census tracts in Los Angeles have elevated lead levels cannot be answered with precision. However, based on the 60 percent confirmation rate in those who were retested it is estimated to be at least 14 percent but less than 23 percent.

Similar tables for Alameda and Contra Costa Counties, not presented here, showed fewer children with elevated levels. Contra Costa results showed between 2 percent and 4 percent, while Alameda showed between 6 percent and 8 percent.

Conclusions

The above data show that there are children in California with elevated blood lead levels. The data show problems in Alameda, Contra Costa and, particularly, Los Angeles Counties. Although not calculable with accuracy, the cost to society of neglecting this problem may be phenomenal. We urge, therefore, that the screening program, including initial screening, diagnostic pediatric management, and source identification and removal, be continued in these counties and expanded to other areas.

Summary

An excess body burden of lead in humans is associated with a variety of health problems. Children, particularly those with pica, the habit of eating nonfood items, are most susceptible to an increased body burden of lead. Although elevated lead levels in children have been shown to exist in cities in the East and Midwest, it had been generally believed that no significant problem existed in the western United States. This paper presents data from a lead screening program which utilized a dual test in which both lead and erythrocyte protoporphyrin were measured. The data show that children with elevated lead levels may be found in California, particularly in an area of southeast Los Angeles, where 14 to 23 percent of the 1,239 children screened had blood lead levels greater than 30 μg per 100 ml of whole blood, simultaneous with erythrocyte protoporphyrin levels greater than 60 μg per 100 ml.

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